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(54) **AXIAL PISTON MACHINE WITH OFFSET POSITIONING ELEMENT AND CAM DISK FOR SUCH AN AXIAL PISTON MACHINE**

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F01B 13/04 (2006.01)

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(58) **Field of Classification Search** 92/57
See application file for complete search history.

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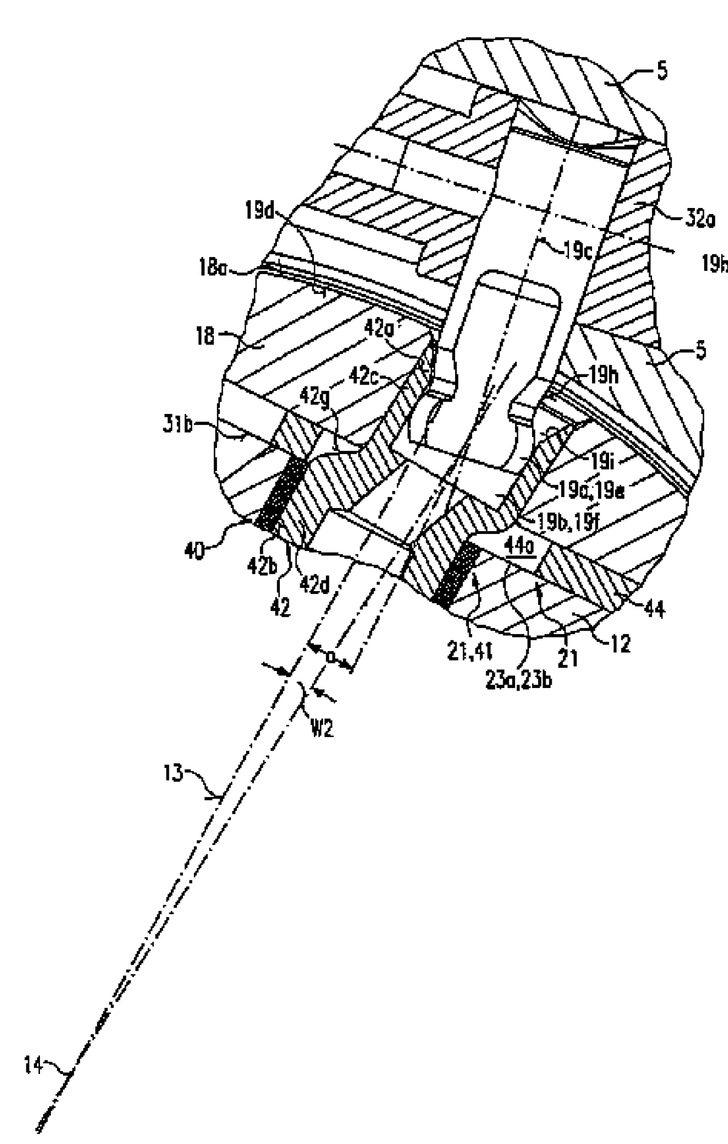
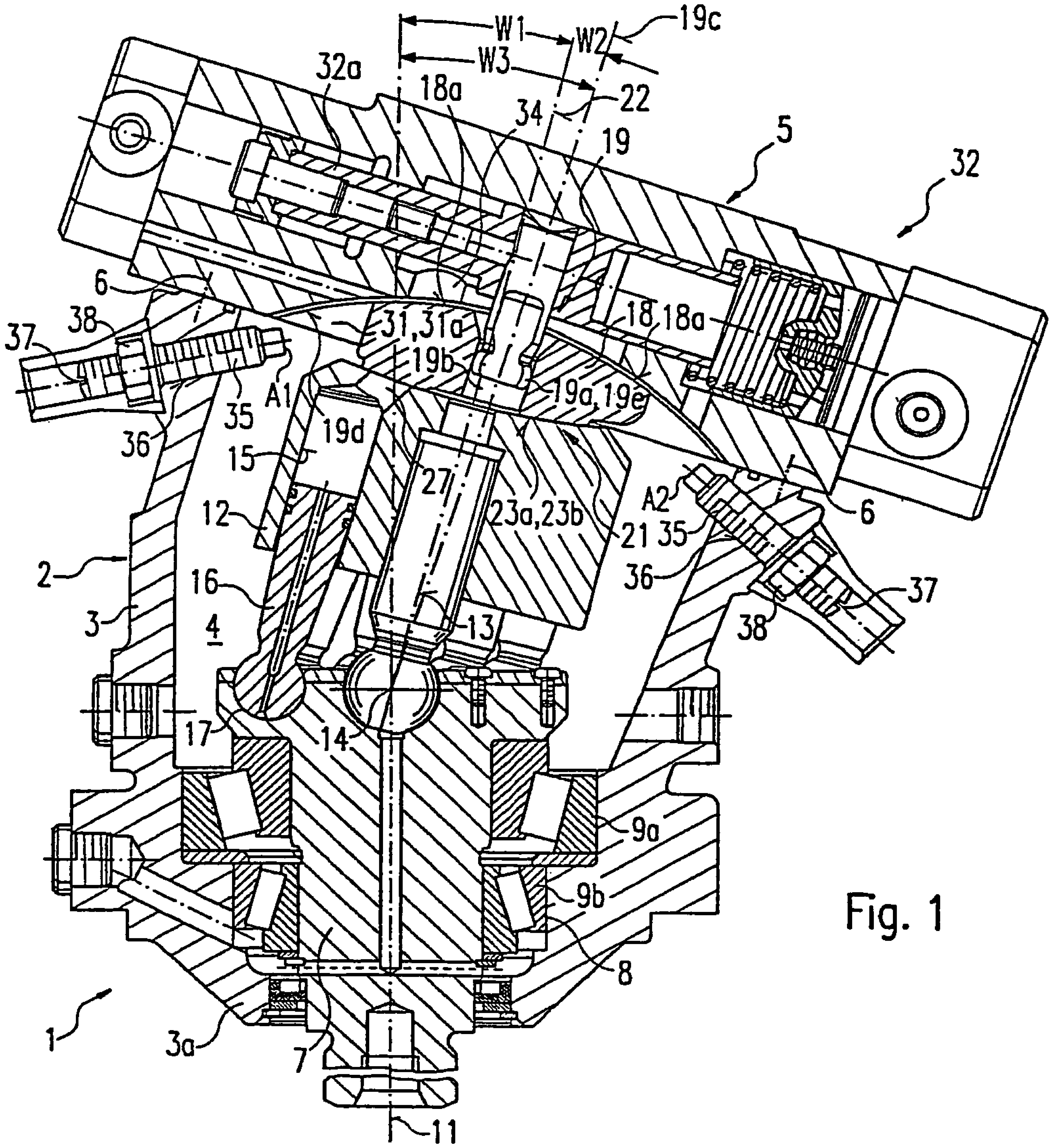
(57) **ABSTRACT**

The invention relates to an axial piston machine (**1**) comprising a housing (**2**) in which a drive disk (**7**) and a cylinder block (**12**) axially disposed next to it are received so as to be rotatable relative to each other about longitudinal center axes (**11**, **13**). These axes run obliquely at an angle (W1) relative to each other in an oblique axis plane (E). A cam disk (**18**) is disposed on the front of the cylinder block (**12**) facing away from the drive disk (**17**) and is supported on the housing (**2**) by means of a positioning device (**19**) with positively engaging positioning elements (**19***a*, **19***b*). A guide element (**21**) having a guide center axis (**22**) running coaxially to the longitudinal center axis (**13**) of the cylinder block (**12**) is disposed on the side facing the cylinder block (**12**). In order to provide for a simple construction and to allow for a step-wise modification of the throughput, the positioning element (**19***b*) disposed on the cam disk (**18**) is set off in the oblique axis plane (E) at an angle to the guide center axis (**22**). The cam disk (**18**) can be mounted in a second position, rotated relative to the guide center axis (**22**) by approximately 180°, in which the positioning elements (**19***a*, **19***b*) are also functionally linked.

8 Claims, 4 Drawing Sheets

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A1
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36
19d
15
27
23a,23b
A2
21
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6
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9a
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3a
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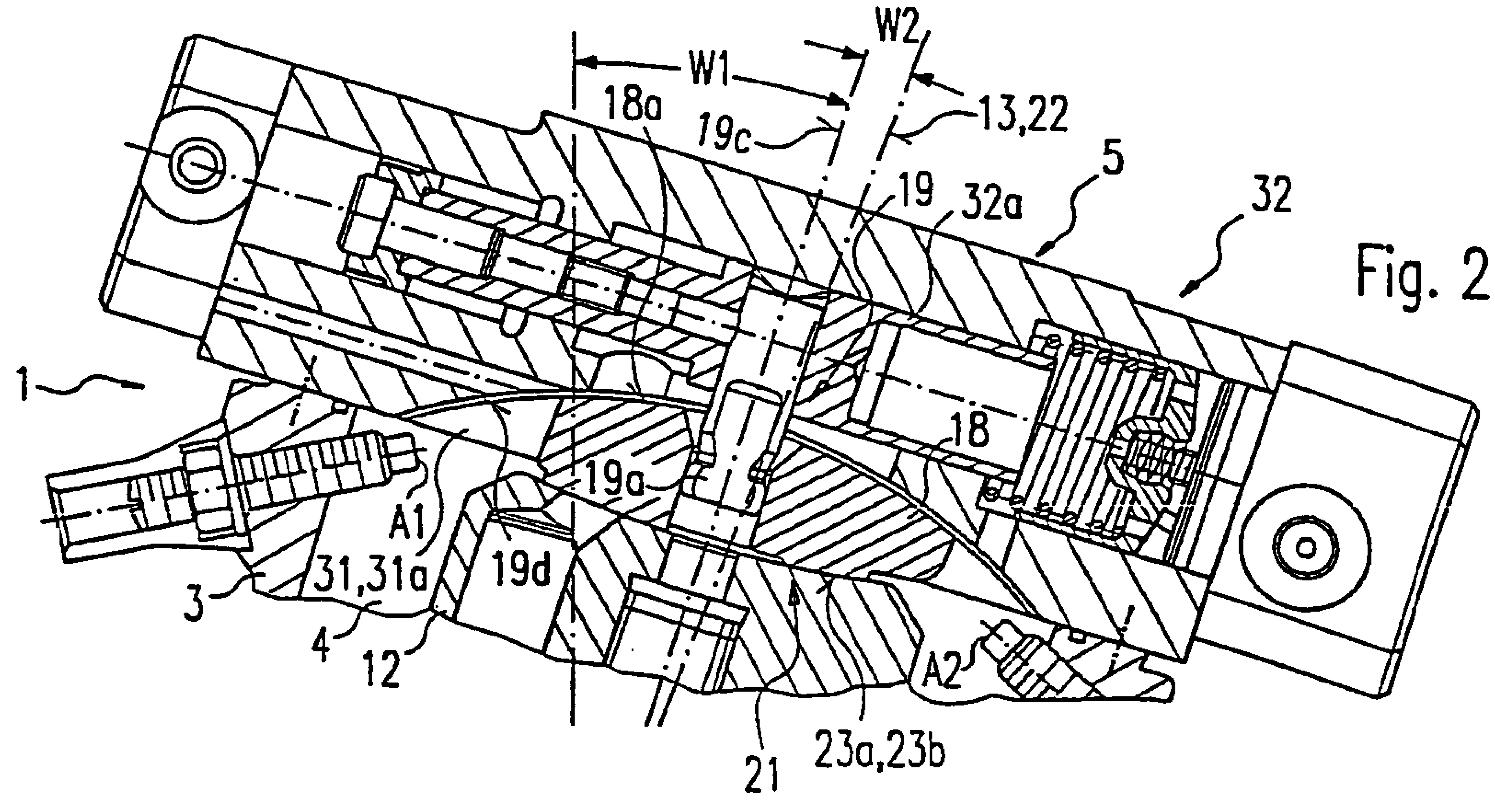
11

Fig. 1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A2
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23a,23b

Fig. 2

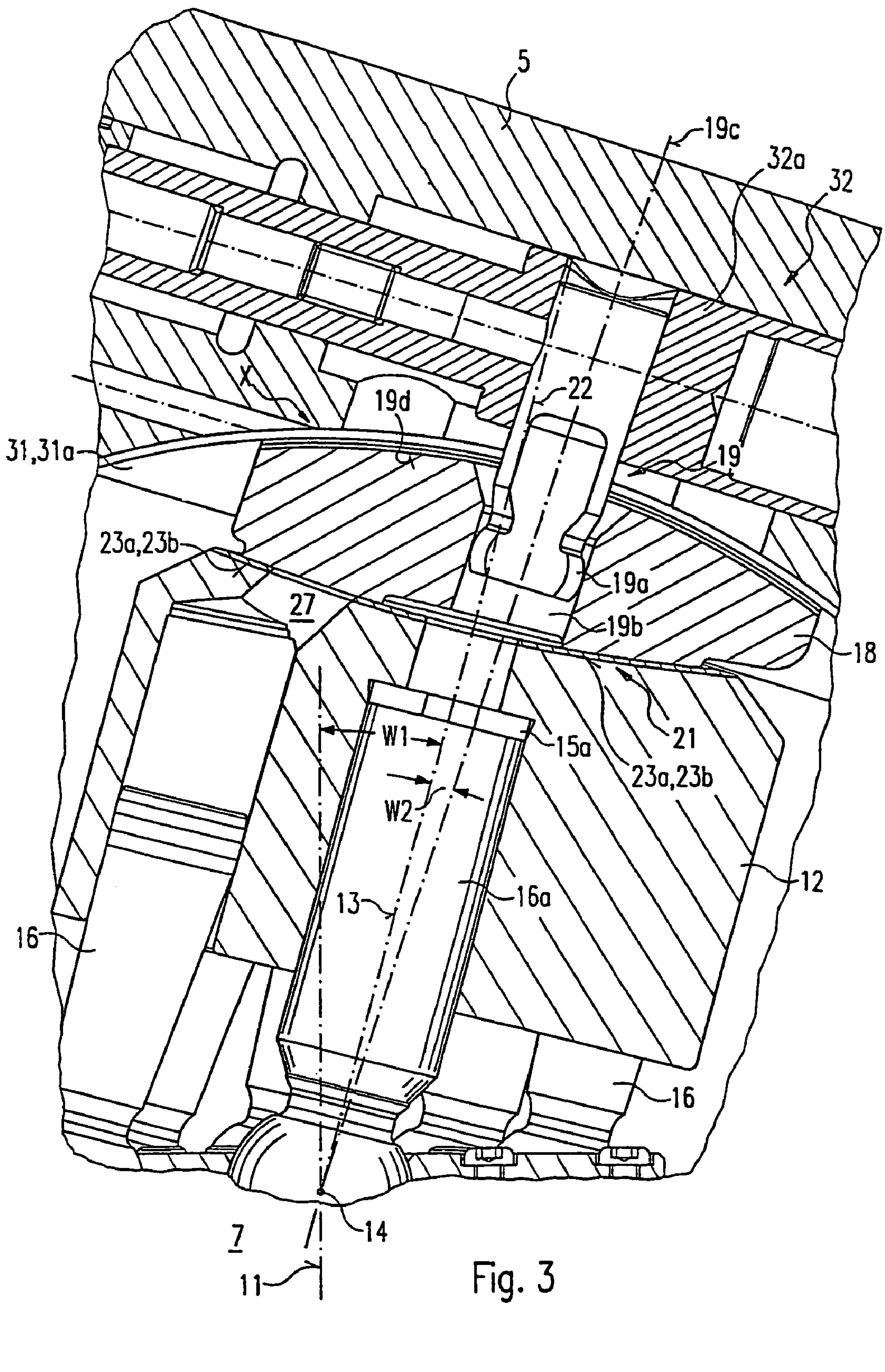
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Fig. 3

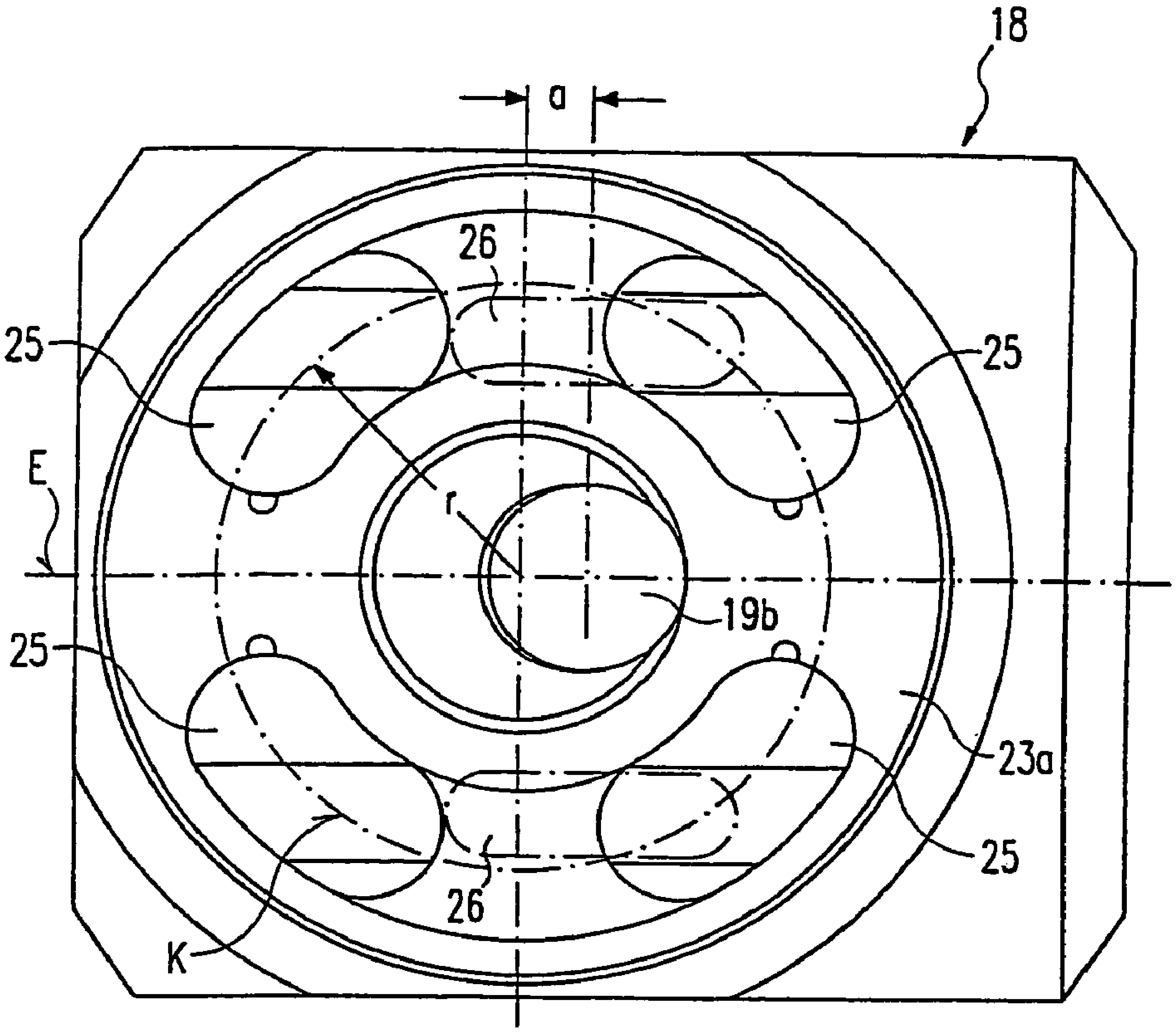


Fig. 4

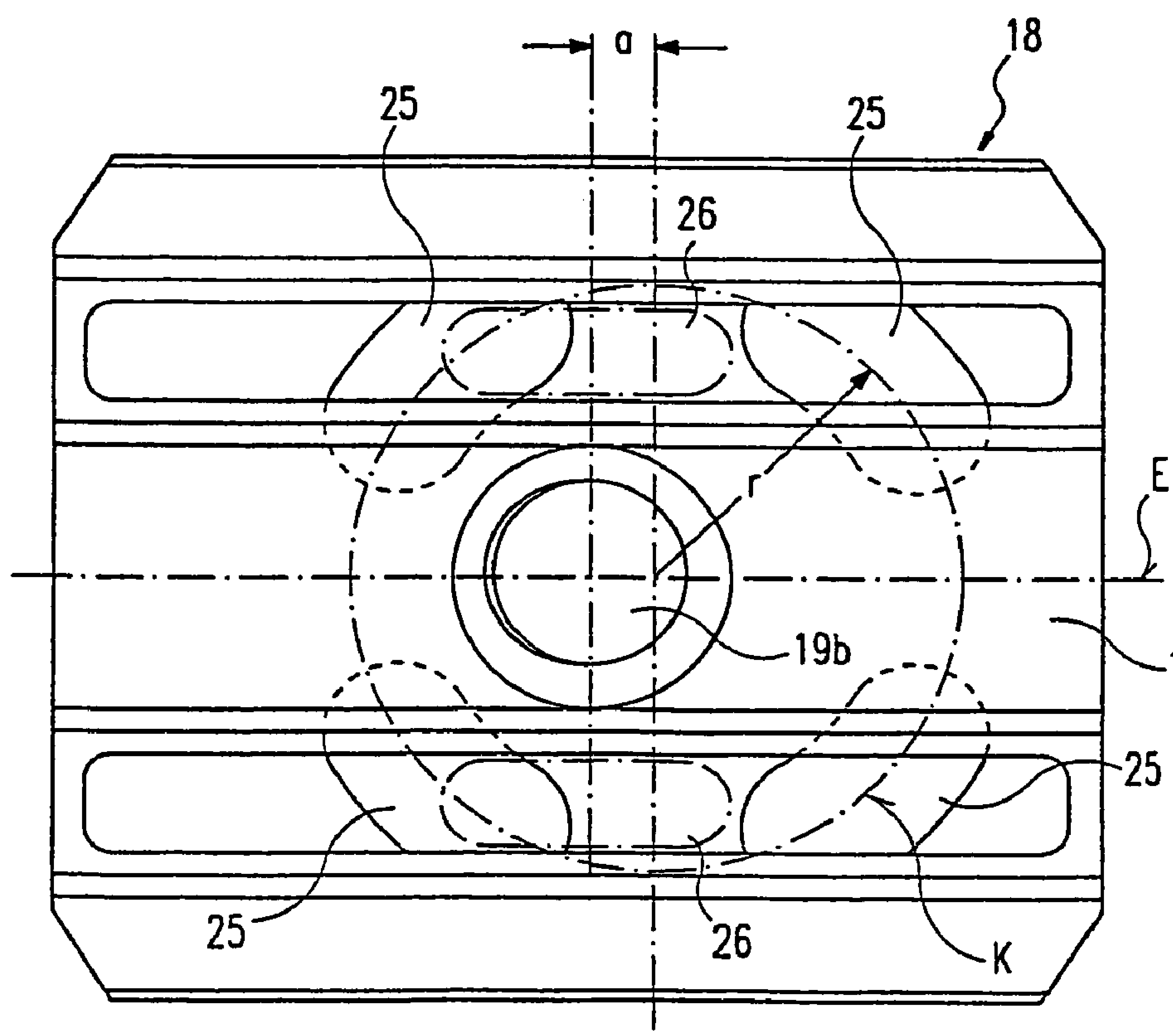
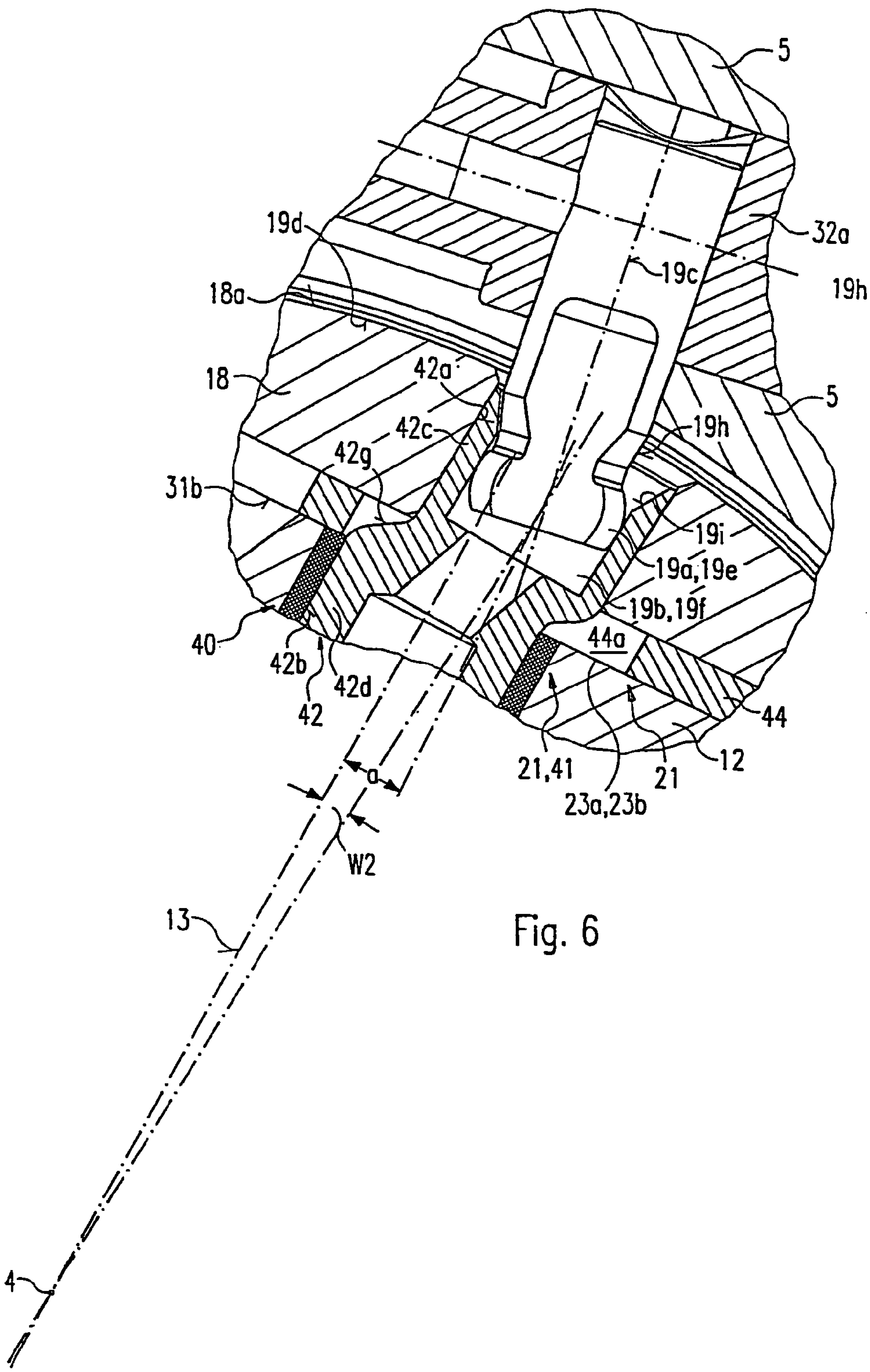


Fig. 5


5
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40
44a
42b
42d
42
44
21,41
12
21
23a,23b
a
W2
13
14

Fig. 6

AXIAL PISTON MACHINE WITH OFFSET POSITIONING ELEMENT AND CAM DISK FOR SUCH AN AXIAL PISTON MACHINE

The invention relates to an axial piston machine and a cam disc for such an axial piston machine.

An axial piston machine of this type is, for example, disclosed in DE 100 30 147 A1 and namely both as an axial piston machine with constant throughput volume and with variable throughput volume.

The throughput volume is varied in this known construction by the cylinder drum and the cam disc being pivoted in the oblique axis plane containing the centre axes of the drive disc and the cylinder drum. To this end a driving connection with positioning elements positively engaging in one another can be provided between the cam disc and the housing or a control block in place of a housing wall. In this connection, the pivoting takes place in a circular arc shaped guide curved about the intersection of the centre axes and extending in the oblique axis plane and in which the cam disc is pivotally guided.

The object of the invention is to design an axial piston machine and a cam disc for such an axial piston machine, ensuring a simple construction, such that a step-wise variation of the throughput volume is possible.

The invention is based on the recognition that, instead of pivoting in a guide, the cam disc can be adjusted by an offset of the cam disc which can be achieved by rearranging the cam disc by rotating it by 180 DEG about its guide centre axis. As a result, two positions of the cam disc are produced, arranged offset to one another in the oblique axis plane and in which the angle between the centre axes of the drive disc and the cylinder drum is variable and therefore the throughput volume is variable.

In an embodiment, the positioning element arranged on the cam disc is transversely offset relative to the guide centre axis in the oblique axis plane, the cam disc being optionally able to be installed in two positions offset by 180° to one another.

In an embodiment, the positioning element arranged on the cam disc is arranged offset relative to the guide centre axis in the oblique axis plane.

The two embodiments according to the invention allow a lateral displacement of the cam disc which leads to variable volume adjustment depending on the oblique axial arrangement. In this connection, one of these two volume adjustments can optionally be carried out by the cam disc being rearranged by rotating it by 180° or the cam disc already being specifically installed during the initial installation in one of its two positions. As a result, the desired throughput volume can be considered during installation and initial installation of the axial piston machine. The size of the throughput volume variation can be determined by the size of the offset dimension, by which the positioning element arranged on the cam disc is offset relative to the guide centre axis.

The two embodiments according to the invention are suitable for variable throughput volumes which can be set. As a result it is possible, when assembling the axial piston machine, to establish whether the throughput volume is to be larger or smaller than a desired throughput volume range.

An offset of less than 10°, in particular of approximately 3°, allows the creation of large flow cross-sections for the flow channels in the cam disc and in the connecting part. Thus flow losses can be reduced and the speed stability and the efficiency of the axial piston machine can be improved.

The invention is also suitable for use in combination with an axial piston machine of which the throughput volume can be set by pivoting the cam disc by means of an adjustment device. With this combination, the embodiment according to the invention firstly allows a displacement of the adjustment range to a minimum direction of, for example, 0° or a maximum direction of, for example, 32° and secondly an increase of the adjustment range when the cam disc is positioned, such that the adjustment path is increased by the offset.

The embodiment according to the invention is thus suitable both for such axial piston machines, in which the cam disc cannot be displaced in its installed position and for such axial piston machines in which the cam disc can be displaced for the purpose of altering the throughput volume in a circular arc shaped guide curved about the intersection of the centre axes of the drive disc and the cylinder drum. In the last described embodiment, the throughput volume can be varied steplessly in the region of the guide. In this embodiment the embodiment according to the invention is preferably suitable for varying the throughput volume in the region of the maximum limit of the adjustment range.

The aforementioned advantages can also therefore be achieved when the embodiment according to the invention is combined with an axial piston machine, of which the adjustment range is smaller than the increased adjustment range which can be achieved by the offset of the cam disc. If the adjustment device of the axial piston machine is designed, for example, for an adjustment range of 0° to 26°, then by a specific installation or rearrangement of the cam disc according to the invention, the pivoting range can moreover be set from 0° to 26° in its one position and in the other position an adjustment range increased by the offset dimension can be set, which however ends before the minimum setting 0°. With an offset dimension of, for example, approximately 3°, in the latter case an adjustment range of 6° to 32° can be set.

A raised portion on the side of the cam disc facing the cylinder block is suitable as a guide element for the cylinder block and which cooperates positively with a correspondingly formed front face of the control block. In an axial piston machine with a rotatably mounted cylinder block, namely a so-called cylinder drum, a rotationally-symmetrically curved design of the guide element and of the front face of the cylinder drum cooperating positively therewith is required.

As a positioning device for positioning the cam disc, a positive engagement known per se between a recess and a pin held therein is well suited to ensure a simple and inexpensive construction.

The invention will be described hereinafter with reference to advantageous designs of an embodiment, in which:

FIG. **1** is an axial piston machine according to the invention with variable throughput volume in axial section;

FIG. **2** is a portion of the axial piston machine in an altered position relative to its throughput volume;

FIG. **3** is an enlarged view of a substantial region of the axial piston machine in the position according to FIG. **1**;

FIG. **4** is a front view of a cam disc of the axial piston machine;

FIG. **5** is a rear view of the cam disc;

FIG. **6** is the region identified by X in FIG. **3** of the axial piston machine in a modified embodiment.

In the axial piston machine shown by way of example and denoted as a whole by **1**, the axial piston machine is of oblique axis construction. This construction comprises a closed housing **2**, with a pot-shaped housing part **3**, of which the housing interior **4** can be releasably closed by a so-called connecting part **5** which is screwed by means of screws **6** shown in outline to the free edge of the housing part **3**. In the housing **2** a drive disc or drive shaft **7** is rotatably mounted which passes through the one base wall **3***a* of the pot-shaped housing **3** in a through hole **8** and is rotatably mounted therein, for example by means of roller bearings **9***a*, **9***b* which are seated in the through hole **8**.

In the present embodiment, in which the drive disc is rotatably mounted, the longitudinal centre axis **11** of the drive disc **7** is simultaneously its rotational axis. Axially mounted in the vicinity of the drive disc **7** is a cylinder block **12** in the housing interior **4** with a longitudinal centre axis **13** which extends obliquely relative to the longitudinal centre axis **11** of the drive disc **7** in an oblique axis plane containing the two longitudinal centre axes **11**, **13**, so that the longitudinal centre axes **11**, **13** include an acute angle W**1** which is open toward the side facing away from the drive disc **7**. The intersection of the longitudinal centre axes **11**, **13** is denoted by **14**.

In the cylinder block **12**, a plurality of piston bores **15** are distributed on its cross-section and arranged parallel, for example, relative to the centre axis **13** and which open out in the direction of the drive disc **7** and in which pistons **16** are mounted which can be displaced to and fro and of which the ends facing the drive disc **7** are supported in a universally pivotal manner on the drive disc **7**. To this end, spherical segment bearings **17** are provided in the embodiment between the pistons **16** and the drive disc **7**.

On the front face of the cylinder block **12** facing away from the drive disc **7** a cam disc **18** is arranged which is supported on the housing **2** by a positioning device **19** and on its side facing the cylinder block **12** comprises a guide element **21**, with a guide centre axis **22** for the cylinder block **12**. The guide centre axis **22** extends transversely to the cam disc **18** and in the centre region of the cam disc **18**, as well as coaxially to the longitudinal centre axis **13** of the cylinder block **12**. This is supported in the direction of the cam disc **18** by guide surfaces **23***a*, **23***b* bearing against one another and by the guide element **21** on the cam disc **18**, transversely to the guide centre axis **22**.

By means of a relative rotation between the drive disc **7** and the cylinder block **12** the pistons **16** are pushed to and fro due to the presence of the axial angle W**1** and, depending on the rotational direction, the pistons **16** drawing in fluid on the one side of the longitudinal centre axis **13** and displacing it on the other side. Thus the fluid flow flows from an inlet, not shown, through control channels **25** in the cam disc **18**, arranged symmetrically on the two sides coaxially to the guide centre axis **22**, through channels **26** in the connecting part **5** extending toward the control channels **25** and through channels **27** in the cylinder block **12** extending from the control channels **25** toward the piston bores **15**, to an outlet, not shown, also arranged on the connecting part **5**.

In the embodiment the guide element **21** is formed by the guide surfaces **23***a*, **23***b*, preferably spherical sector-shaped, being curved concentrically to the guide centre axis **22** and the longitudinal centre axis **13** and namely curved in a concave manner on the front face of the cylinder block **12** and curved in a convex manner on the opposing front face of the cam disc **18**, so that the guide surface **23***a* defines a raised and convex guide element **21**, as is known per se.

The positioning device **19** is formed by a positioning element **19***a* on the connecting part **5** and a positioning element **19***b* cooperating therewith on the cam disc **18**. The positioning elements **19***a*, **19***b* cooperate positively, such that a movement directed transversely to the guide centre axis **22** and a movement of the cam disc **18** away from the cylinder block **12** is positively locked by the positioning device **19** on the connecting part **5**. The positioning elements **19***a*, **19***b* engage in one another along an engagement axis **19***c*. An embodiment of the positioning elements **19***a*, **19***b* which can be easily assembled and disassembled is then achieved, if it can be assembled and disassembled by an assembling and disassembling movement of the cam disc **18** and the connecting part **5** directed along the guide centre axis. In such an embodiment the positioning element **19***b* on the cam disc **18** is accessible to the positioning element **19***a* on the connecting part **5** from the connecting face, on which the connecting part **5** is located.

In the embodiment the positioning element **19***b* is formed on the cam disc by a recess open from, and therefore accessible from, the connecting part **5** and in which a positioning pin protruding from the control part **5** toward the cam disc **18** is held with slight motional clearance. In this connection, the positioning device **19** is constructed such that the centre axis **19***c* of the positioning device **19** oriented transversely to the cam disc **18**, is laterally offset relative to the guide centre axis **22** in the oblique axis plane E containing the two centre axes **11**, **13**. The corresponding offset dimension a is produced by the offset angle W**2**. As a result, the positioning element **19***a* is also laterally offset relative to the guide centre axis **22** by the offset angle W**2**. The offset angle W**2** is smaller than approximately 10° and is preferably approximately 3°.

The positioning device **19** further comprises a bearing face **19***d* on the connecting part **5** facing the cam disc **18**. The cam disc **18** rests with one bearing face **18***a* on its front face facing the connecting part **5** on the bearing face **19***d* and is thereby supported on the side facing away from the cylinder block **12**.

The positioning device **19** is moreover constructed such that the cam disc **18** can be installed into an offset position shown in FIG. **2** from the offset position shown in FIGS. **1** and **3** and in which it is rotated by 180° about the guide centre axis **22**, and vice versa. Rearranging the cam disc **18** into the positions shown in FIGS. **1** and **2** leads to a lateral offset of the cam disc **18** and the cylinder block **12** guided thereon, this offset being double the size of the offset a produced by the offset angle W**2**.

The axial piston machine **1** disclosed thus far can therefore be assembled by installing the cam disc **18** in a specific assembly position or by rearranging the cam disc **18** into positions rotated by 180°. In these positions of the cam disc **18** the axial piston machine **1** can be set to two throughput volumes of variable sizes and can be adjusted in one step.

In the embodiment shown, the cam disc **18** can be laterally pivoted to and fro and fixed in addition to the aforementioned positions in a pivoting guide **31** extending parallel to the oblique axis plane E, the pivoting guide **31** being curved about the intersection **14** of the longitudinal centre axes **11**, **13**. Moreover, an adjustment device **32** is provided, by means of which the cam disc **18** in the rotating guide **31** can be steplessly adjusted to and fro in the oblique axis plane E between a minimum position, for example with a pivoting angle of 0° and a maximum position, for example with a pivoting angle of 26° and fixed in the respective pivoting position.

In the embodiment the pivoting guide **31** is formed by a guide groove **31***a* in the wall of the connecting part **5** facing the housing interior **4**, the base of the guide groove **31***a* being formed by the bearing surface **19***d* and being curved in a concave manner about the intersection **14** and forming a curved guide and bearing surface **19***d*, on which the cam disc **18** slideably rests with its correspondingly convex curved bearing surface **18***a*. The adjustment device **32** is moreover incorporated in the connecting part **5** and, for example, formed by an adjusting slider **32***a* which can be specifically displaced hydraulically transversely to the guide centre axis **22** and to and fro in a slide guide in the oblique axis plane E and can be fixed in the respective setting. The connecting part **5** is arranged obliquely relative to the centre axis **11** in the oblique axis plane and with the centre axis **11** includes an acute angle W**3** which corresponds to half the angle of the pivoting angle region and in the embodiment is approximately 16°. In this connection, W**3**=16° for the two exemplary adjustment ranges 0-26° and 6-32°.

The positioning element **19***a* arranged on the connecting part **5** is fastened in the embodiment to the adjusting slider **32***a* and can be displaced to and fro therewith in a corresponding free space **34** and slot, the cam disc **18** being driven by means of the cooperation of the positioning elements **19***a*, **19***b*. In order to ensure positioning in the offset oriented transversely to the guide centre axis **22** in the oblique axis plane E, in spite of the variable moving directions between the positioning elements **19***a*, **19***b* (straight, curved), the pin-shaped positioning element **19***a* plunges with a circular rounded positioning head **19***e* into the recess **19***f* in the cam disc **18** forming the counter positioning part.

With such a steplessly variable axial piston machine **1**, the embodiment according to the invention allows either a reduction or increase in the throughput volume of the axial piston machine or a specific setting of the axial piston machine from the outset by a corresponding rearrangement or initial assembly.

A particular advantage of the embodiment according to the invention can be seen by the embodiment according to the invention being restricted to the design of the cam disc and therefore the embodiment according to the invention is suitable for resetting the piston machine, without its other parts having to be altered. Thus, for example by a corresponding offset of the cam disc, the adjustment range of the adjustment device can be increased by the offset dimension, without it requiring itself a corresponding enlargement of the adjustment device. This becomes clear when one considers that in an adjustment device with an adjustment range of, for example, approximately 0 to 26° the embodiment according to the invention retains this adjustment range in the one position of the cam disc and in the other position results in an adjustment range which is increased by the offset dimension of the cam disc, but which ends at the offset dimension before the zero point of the adjustment device. Even when the axial piston machine is installed from the outset with only one of the two pivoting angle regions, the two pivoting angle regions can be produced with a high similarity of parts.

The end positions of the pivoting regions can be defined by stops A**1**, A**2**, which are adjustable and can be incorporated in the connecting part **5** as end stops for the adjusting slider **32***a*. In the embodiment, a minimum stop A**1** and a maximum stop A**2** respectively formed by an adjustment screw **35** which passes through the peripheral wall of the housing **2** in a threaded hole **36**, approximately in the oblique axis plane E, protrudes into the housing interior **4** and can be rotated externally by a rotary tool which can be applied to a rotatable engagement member, for example a slot **37** and can be fixed, for example by means of a lock nut **38**.

In the aforementioned embodiments the cam disc **18** is non-displaceably positioned in each pivoting position relative to the cylinder block **12** in the pivoting plane E. Thus between the cam disc **18** and the cylinder block **12** a positioning device **41** acts which positions these two parts non-displaceably on one another in the pivoting plane E. This positioning is carried out by the convex form of the cam disc **18** in the pivoting plane E and the concave form of the cylinder block **12**. Therefore, the cam disc **18** is able to drive the cylinder block **12** when it is displaced in the pivoting plane E, the positioning device **41** acting as a drive device. The guide element **21** thus allows the rotation of the cylinder block **12** during the positioning.

This positioning device **41** is prone to an effective clamping action between the cam disc **18** and the cylinder block **12** due to the relatively slight arcuate form of the guide surfaces **23***a*, **23***b*.

It is therefore advantageous to stabilise the positioning device acting between the cam disc **18** and the cylinder block **12**, such that the aforementioned clamping action and greater wear and tear and increase in temperature resulting therefrom can be reduced or prevented.

In the embodiment according to FIG. **6** the positioning device **41** is formed by an additional pin connection acting between the cam disc **18** and the cylinder block **12**, with a positioning pin **42** which is held in an appropriate manner respectively in positioning recesses **42***a*, **42***b* in the cam disc **18** and in the cylinder block **12** and in addition passes through the gap **31***b* therebetween. Moreover the pin portions **42***c*, **42***d* of the positioning pin **42** held in the positioning recesses **42***a*, **42***b* are offset to one another and cranked by the offset dimension a and the angle W**2** and one or both of these pin connections can be installed in the positions of the cam disc **18** rotated by 180°. The positioning recesses **42***a*, **42***b* and the pin portions **42***c*, **42***d* preferably comprise a round cross-section. Due to the offset a the positioning pin **42** is, relative to the cam disc **18**, unrotatably mounted in the cam disc **18**. In the transitional region **42***g* between the pin portions **42***a*, **42***b* the positioning pin **42** can comprise side portions extending obliquely, which preferably are convex and concave and merge with the pin portions **42***c*, **42***d*, as the drawing shows. The positioning recess **42***b* forms a rotary bearing **40** for the cylinder block **12**. This can be a roller- or friction bearing which can comprise a sliding bushing **12***a* fastened to one of the rotary bearing parts.

In the embodiment according to FIG. **6** the positioning recess **19***b* is arranged in the pin portion **42***c*, it being adapted relative to its cross-sectional form and size to the cross-sectional size and form of the positioning element **19***a* and able to be formed by a blind hole open on the front face. The positioning recess **19***b* is preferably formed by a longitudinally extending channel and open toward a guide hole **15***a* receiving a centre guide pin **16***a*. As a result, the lubrication of the positioning elements **19***a*, **19***b* is improved.

Furthermore, the positioning elements **19***a*, **19***b* can be constructed as in the embodiment according to FIG. **3**, namely with a waist **19***h* on the positioning head **19***e* and a recess widening **19***i* on the perforated edge facing the housing and connecting part **5**, in order to increase the available pivoting region.

A sliding layer **44** arranged between the cam disc **18** and the cylinder block **12** made from antifriction and/or hard-wearing material can be formed by a disc which can be fastened to the cam disc **18**, for example by soldering, welding or bonding. A hole **44***a* penetrated by the positioning pin **42** in the disc is large enough for the transitional region **42***g* therein to have a free space in the two offset positions.

In the embodiment according to FIG. **6** the guide surfaces **23***a*, **23***b*, contrary to the aforementioned embodiment, are planar surfaces; they can however also be of spherical sector-shaped concave and convex construction, as is the case in the aforementioned embodiment.

The positioning recess **42***b* and the pin portion **42***d* are preferably arranged coaxially to the longitudinal centre axis of the cylinder block **12**. The positioning recess **42***a* and the positioning pin **42***c*, as well as the positioning recess **19***b*, can be offset parallel relative to the longitudinal centre axis **13** and the offset a. In the embodiment the positioning recess **42***a*, the pin portion **42***c* located therein and the positioning recess **19***b* are arranged together, rotated by the angle W**2** relative to the longitudinal centre axis **19**.

The rearrangement of the cam disc **18** can take place when the housing cover and connecting part **5** are removed, by the cam disc **18** being removed from the pin portion **42***c*, rotated by approximately 180° about the centre axis **13** and then replaced, or by the cam disc **18** being lifted with the positioning pin **42** out of the positioning recess **42***b*, rotated by 180° approximately about the centre axis and again inserted into the positioning recess **42***b*. As far as possible, the rearrangement can also take place by the positioning pin **42** being rotated by 180 DEG in the positioning recess **42***b*.

The invention claimed is:

1. Axial piston machine with a housing, in which a drive disc and a cylinder block axially arranged in its vicinity are rotatably mounted relative to one another about longitudinal center axes, which extend obliquely to one another by an angle (W**1**) in an oblique axis plane (E), a plurality of piston bores being arranged in the cylinder block and in which pistons are displaceably guided axially to and fro, of which the piston ends facing the drive disc are supported in a universally pivotal manner on the drive disc, on the front face of the cylinder block facing away from the drive disc a cam disc being arranged which is supported on the housing by a first positioning device with positively cooperating positioning elements and on its side facing the cylinder block comprising a guide element with a guide center axis extending coaxially to the longitudinal center axis of the cylinder block, wherein

at least one of said positioning elements is arranged on the cam disc offset transversely to the guide center axis in the oblique axis plane (E) and the cam disc is able to be installed in a further position rotated by approximately 180° about the guide center axis, in which the positioning elements also cooperate, said cylinder block being positioned positively against relative displacement in the oblique axis plane (E) by a second positioning device, said second positioning device being formed by a positioning pin which is seated with a pin portion in a positioning recess in the cam disc and is seated in a positioning recess of the cylinder block with a positioning pin offset in the oblique axis plane (E) by the offset (a).

2. Axial piston machine according claim **1** wherein the positioning element is offset relative to the guide center axis by an offset angle (W**2**) which is smaller than approximately 10°.

3. Axial piston machine according to claim **2**, wherein the offset angle (W**2**) is approximately 3°.

4. Axial piston machine according to claim **1**, wherein the pin portion seated in the cylinder block is rotatably mounted in the cylinder block by a rotary bearing.

5. Axial piston machine according to claim **1**, wherein the pin portion seated in the cam disc forms a positioning element for the first positioning device.

6. Axial piston machine according claim **5**, wherein the positioning element is formed by a positioning recess open on the front face.

7. Axial piston machine according to claim **1**, wherein between the cam disc and the cylinder block a disc with a hole is arranged for the positioning pin which preferably is large enough so that in the offset position of the cam disc a transitional region of the positioning pin preferably extending obliquely has a free space in the hole.

8. Axial piston machine according to claim **1**, wherein the positioning pin comprises an elongate through hole which preferably opens out into the positioning recess.

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